areas of Anisopterid larvae seems to strengthen this view. In the rectal gills of these larvae, the minute branches of the tracheæ are separated from the water of the rectum by a very thin epithelium. This seems to show that respiration takes place most actively through a thin epithelium.

II. THE TRACHEAL SUPPLY OF THE RECTUM OF THE LARVA OF ARGIA TALAMANCA FROM JUAN VIÑAS, COSTA RICA.

BY JANET P. JAMIESON.

The rectal epithelium of the water-fall dweller, *Argia talamanca*, presents three main longitudinal folds, one that is "dorsal and a little to the left of the median plane," a second that is "left latero-ventral" and the third that is "right lateral." These folds (Fig. 1.) correspond in position with those of the water-fall dweller *Thaumatoneura* described by Calvert (*Entomological News*, Vol. XXVI, p. 387, and plate XVII, fig. 1.) Those of *A. talamanca* are, however, deeper as may be seen by comparing photographs of the transverse sections, and show a greater complexity. In some parts of the rectum the free edges of the three folds appear to meet in the center of the lumen of the gut. Between the bases of these primary folds the epithelium thins out and becomes darkly pigmented. From the base of each primary fold, is given off a secondary shallower fold, to the right in the case of the dorsal fold, to the left in the case of the left latero-ventral fold and ventrally in the case of the right lateral fold.

Toward the hind end of the rectum the secondary folds disappear and the main folds have practically no depth; this gives an almost cylindrical shape to the hind part of the rectum.

The larva of *Argia putrida* from the vicinity of Philadelphia, described in the preceding paper by Miss Cullen, differing from *A. talamanca* in that it lives in streams of continuously flowing water, shows three simple shallow folds in the rectal epithelium, one dorsal, one right lateral and one left lateral. The epithelium is much denser and thicker than in this water-fall dweller of the same genus, and the thin pigmented areas between the bases of the folds are not so broad.

It has been suggested by Calvert that the more extensive surface area afforded by the greater folding of the rectum together with the thinner, less dense nature of the epithelium of the water-fall dwellers may aid these larvae materially in procuring a supply of

oxygen from the rectum that supplements the supply obtained by the gills when the larva is in the water. The caudal gills of *A. talamanca* are much shorter than those of *A. putrida*. This suggests that there may be a definite ratio between the shortness of the gills and the complexity of the rectal epithelial folds. This theory is strengthened by the fact that Anisopterous larvæ, as described

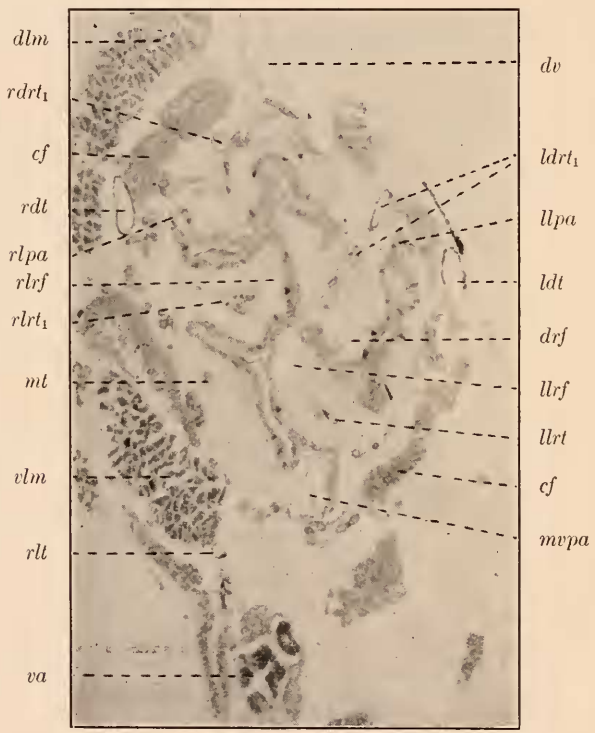

Fig. 1. Transverse section of abdominal organs of larva of *Argia talamanca* ♀ near the hind end of the 8th segment (TS. 12 of row 6, slide 2), seen from its anterior face. Cuticle and hypodermis removed before embedding, also on the left side (right in the figure) the longitudinal muscles. Photographed by Mr. H. A. Walters, using Leitz ocular 4, objective 3. Enlarged 85 diameters.

cf, connective tissue and fat.
dlm, dorsal longitudinal muscle.
drf, dorsal rectal fold.
dv, dorsal vessel.
ldrt$_1$, left dorsal rectal trachea.
ldt, left dorsal trachea.
llpa, left lateral pigmented area.
llrf, left latero-ventral rectal fold.
llrt, left lateral rectal trachea.
llt, left lateral trachea (lies outside of the field of this figure).
mt, Malpighian tubule.
mvpa, mid-ventral pigmented area.
r, rectum.
rdrt$_1$, right dorsal rectal trachea.
rlpa, right lateral pigmented area.
rlrf, right lateral rectal fold.
rlrt$_1$, right lateral rectal trachea.
rdt, right dorsal trachea.
rlt, right lateral trachea.
va, vagina.
vlm, ventral longitudinal muscle.

by Tillyard (*Proceedings of the Linnean Society of New South Wales*, 1915, Vol. XL, Part 3, August 25), have a much greater folding of the rectal epithelium and no caudal gills. To quote him: The rectum presents "six longitudinal double rows of lamellate folds." It is within the thicker, unpigmented portion of the rectal epithelium of *A. talamanca* that the fine ends of the tracheoles which reach the epithelium are embedded. Though the number of these embedded tracheoles is small, numerous tracheæ were traced into the folds and almost to the epithelium. This would suggest that diffusion of oxygen takes place more easily through the unpigmented portions of the folds. The secondary folds increase the diffusion area. The fact that no tracheoles were traced through or even up to the pigmented epithelium between the folds suggests that these areas are reserved for the osmosis of carbonic acid gas from the body tissues into the rectum. For says Tillyard, "It is well known . . . that chitin is a colloid substance which admits of the passage through it of gases by diffusion, and is particularly partial to carbonic acid gas."

The absence of folding of the epithelium at the extreme end of the rectum probably merely facilitates the quick and constant flow of water.

The rectal tracheæ.—The tracheæ that supply the rectum of *A. talamanca* have been studied from a series of transverse sections prepared by and in the possession of Dr. Calvert. Owing to the decay of the anterior rectal epithelium some smaller tracheoles may have been lost.

Two main dorsal longitudinal tracheæ have been traced, one on the left (*ldt* of figs. 1 and 2), the other on the right (*rdt*).

These divide at the posterior end of the ninth segment respectively into the left caudal gill trachea (*lcgt*) and left median caudal gill trachea (*lmcgt*) and into the right caudal gill trachea (*rcgt*) and the right median caudal gill trachea (*rmcgt*).

Within the posterior half of segment VIII arise from the longitudinal dorsal tracheæ, a right dorsal rectal trachea ($rdrt_1$) and a left dorsal rectal trachea ($ldrt_1$), both of which pass mesad and caudad into the dorsal longitudinal rectal fold where they divide and subdivide. Some of the smaller tracheoles enter the epithelium, but no anastomoses were observed.

From the lateral tracheæ (*rlt* and *llt*), which are connected with the dorsal longitudinal trunks in the middle of segment VIII, there come off ventrally in the anterior half of segment VIII, the lateral

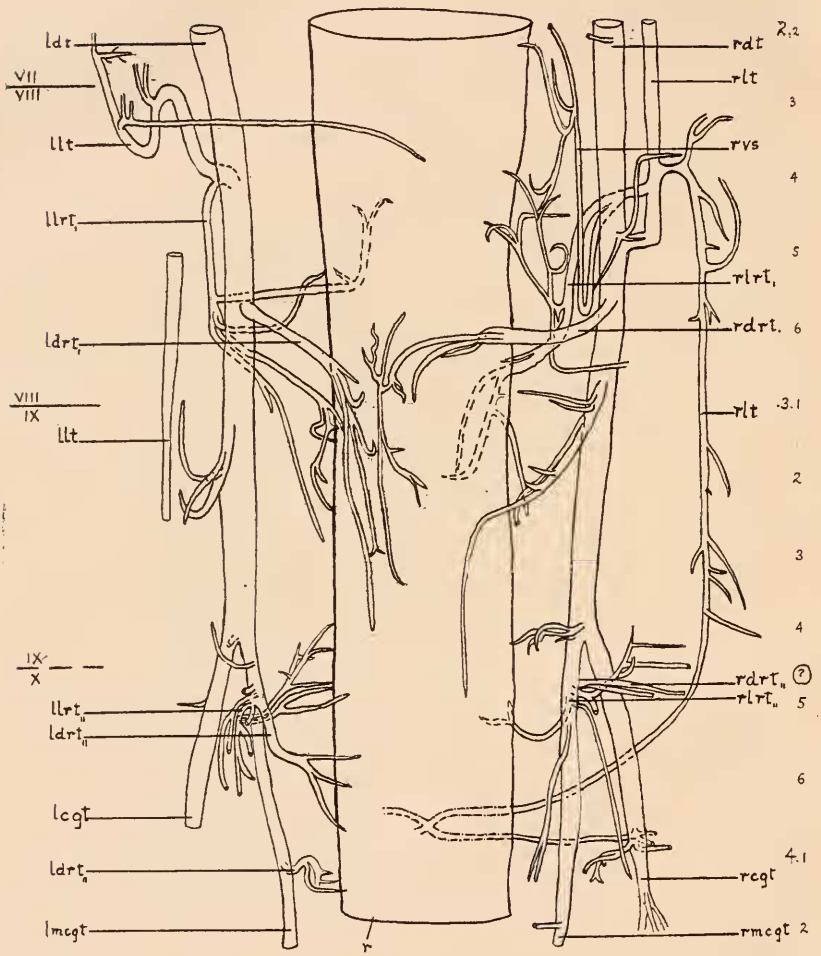

Fig. 2. Diagram of the tracheation of the rectum of larva of *Argia talamanca*, reconstructed from sections. To avoid confusion the tracheæ are represented as lying farther to right and to left from the gut and from each other than is actually the case (compare Fig. 1). Of the tracheæ which supply the gut walls, those which run on the dorsal surface or enter the dorsal longitudinal fold are shown in solid lines; those which run on the ventral surface or enter the lateral folds are shown in broken lines. The ventral anastomosis is shown in dots and dashes. The Roman numerals on the left side indicate the boundaries of the respective abdominal segments; the larger Arabic numerals on the right, the microscopic slides and the smaller Arabic numerals the rows of sections on each slide of the series corresponding to that part of the diagram represented as at the same horizontal level. Each row comprises about 30 sections. Abbreviations as in Figure 1 and as explained in the text.

rectal tracheæ (*rlrt*$_1$ and *llrt*$_1$). Each of these passes mesad and caudad and enters the lateral longitudinal rectal fold of its respective side. The origin of the right lateral rectal trachea differs slightly from that of *Thaumatoneura* as worked out by Calvert. Subdivision of these tracheæ occurs and some of the tracheoles enter the epithelium. No anastomosis has been found here. A smaller posterior rectal supply (*llrt*$_{11}$ and *rlrt*$_{11}$), is received by the lateral rectal folds from the left and right median caudal gill tracheæ respectively. Some of these tracheoles also enter the epithelium, but no anastomosis occurs.

A small posterior dorsal supply (*ldrt*$_{11}$) is received by the dorsal longitudinal fold and by the epithelium from the left median caudal gill trachea. The corresponding (?) group on the right has been traced laterad through and around the muscle fiber mass toward the periphery of the body.

The last two paragraphs show slight differences between *Thaumatoneura* and *Argia talamanca*.

Calvert's statement for *Thaumatoneura* may be quoted here for *A. talamanca*. "The only anastomosing tracheæ which have been discovered are the posterior terminations of the right and left [?] lateral longitudinal tracheæ which, assuming a ventral position, meet on the mid-ventral line ventrad of the alimentary canal; in this anastomosis (*anas*) take part also a branch from the right and a branch from the left [?] lateral caudal gill trachea." The interrogation marks signify an incomplete tracing in *Argia talamanca* due to maceration of parts of the anastomosing tracheæ from the left side.

I think I may say that *all* the tracheæ, large and small, that were traced possessed a black pigment that added materially to the ease of tracing. As has been observed for *Thaumatoneura*, this pigment presents the same appearance as that of the areas between the three longitudinal folds of the rectal epithelium.

For material, directions and suggestions in my work I am indebted to Dr. P. P. Calvert, whose treatment of *Thaumatoneura* I have followed for *Argia talamanca*. The sections studied were of "larva No. 2," ♀, from the "nearer waterfall," Juan Viñas, Costa Rica, March 23-26, 1910, which died in attempted rearing; its condition is, therefore, histologically poor. The locality has been described by Calvert in his *Thaumatoneura* paper cited.